EDITORIAL RESEARCH REPORTS

1961
Vol. I

TEACHING BY MACHINE

by

Helen B. Shaffer

No. 4
Jan. 25

Editorial Research Reports
1156 Nineteenth Street, N.W
Washington

TEACHING BY MACHINE

ADVENT of the machine as a teaching device presages, in combination with educational television, the most drastic change in techniques of mass instruction since invention of the printing press. Printing by machine was responsible for development of the textbook, which gave students identical texts to study. Television and motion pictures are making it possible to extend indefinitely the number of students who may be taught simultaneously by a single teacher. With the read-and-respond teaching machine, now the object of intensive experimentation, automation of education takes another long step forward. The machine, or rather the material doled out by the machine, takes over functions of both teacher and textbook.

Televised and filmed courses of instruction have already reached a high level of acceptance and are expected in time to become routine in a majority of schools. The teaching machine, while pre-dating television by a score of years, is finally attracting the serious attention of school authorities. It is becoming increasingly clear that all of these devices will eventually be widely used in American schools, bringing with them revolutionary changes in the educational process.

Enthusiastic proponents of the teaching machine go so far as to predict that it will some day displace the teacher and the standard textbook as agencies for imparting basic knowledge to young minds. But the classroom teacher will not become obsolete. He or she will be freed from routine teaching chores to serve more effectively as mentor and counselor to students. Their reading may then range more widely and deeply because texts can be written on the assumption that fundamental facts have already been acquired from mechanical instructors. The teaching machine leads pupils individually along the educational path by presenting questions and checking the answers for accuracy, both by mechanical means.[1]

[1] For description of different types of machines, see pp. 68-71.

Norman Crowder, who teaches airmen electronics with the aid of an "Auto Tutor," predicted on Nov. 10 that by the late 1960s most of the systematic teaching in American schools and colleges would be done through teaching machines and special texts related to the automated material. A psychologist-experimenter has pictured the classroom of the future with "walls lined with exotic machines, [resembling] nothing so much as the emporiums of Las Vegas." [2] Even more cautious investigators of the new devices seem convinced that they will soon invade the classroom in force.

Attitude of Educators Toward Mechanization

Experimentation with teaching machines over three decades has brought their technological development to an advanced stage. The machines were devised originally by psychologists to test theories about the learning processes of the human mind. A good deal of the recent development work was sponsored by the armed forces, which had imperative need to find more efficient ways of training technical specialists. Now educators are giving keen attention to the possibility of making general use of teaching machines.

Members of virtually every important educational organization have been told that the teaching machine, for good or ill, is about to descend upon them. Finley Carpenter of the University of Michigan, addressing the 1960 meeting of the American Association of Colleges for Teacher Education, warned teachers to keep abreast of teaching-machine developments. "Despite the lack of sufficient data," he said, "the machine-learning movement appears to be the most promising development in education since the turn of the century. . . . Trends thus far indicated . . . suggest that automated instruction can assume a valuable role in education." [3] The journal of the Department of Audiovisual Instruction of the National Education Association likewise editorialized: "Regardless of the response evoked in each of us individually by the concept of 'teaching by machine,' we cannot deny the impact this device is making on modern education." [4]

Summarizing the responses of 100 educators to an end-

[2] Lloyd E. Homme, "The Rationale of Teaching by Skinner's Machines," *Teaching Machines and Programmed Learning* (1960), p. 136.

[3] American Association of Colleges for Teacher Education, *13th Year Book* (1960), p. 117.

[4] *Audiovisual Communication Review*, Supplement I, March-April 1960, p. 3.

of-year questionnaire, N.E.A. reported the view that the passing of automated teaching "from experiment to classroom experience" had been a significant advance of 1960.[5] Teaching machines were listed in the purchase guide for state school administrators for the first time last year. The Montgomery County (Md.) school system plans to conduct experiments with teaching machines among 1,600 pupils, beginning next September. New York City has already started to train some teachers in the techniques of teaching by machine, and the Los Angeles school system has assigned a specialist to keep up with developments in the field.

Rapid mechanization of instruction is apparently being held up only by an insufficiency of instructional material for machine teaching in the various subjects. The significant new research on teaching machines is taking place in this area, known to the specialists as "programming." Wilbur Schramm, director of the Institute for Communication Research at Stanford University, has called programming development a "rush job." The textbook, he points out, developed slowly over a period of several hundred years. But the present need for a time-saving, labor-saving educational device is so great that educators should at once exert every effort to "understand, learn to use . . . evaluate the worth of these devices" and to prepare appropriate materials for them.[6]

Research on Programs for Teaching Machines

Teaching machines have been used in experimental classes in more than a dozen colleges and universities and in the grades of elementary schools. Funds for research have been flowing into projects of this kind in increasing amounts from government and private sources. A provision of the National Defense Education Act of 1958 authorizing expenditure of $18 million over a four-year period for research and experimentation in educational media has helped to advance teaching machine development.

A project concerned with development of teaching machine programs and assessment of their effectiveness has been in progress at Harvard University for some years

---

[5] *Education U.S.A.*, Dec. 29, 1960, p. 1.

[6] Stanford Institute for Communication Research, *New Teaching Aids* (1960), pp. vii-ix.

under direction of the psychologist B. F. Skinner, with support from the Ford Foundation. Skinner received a federal grant of $250,000 early in 1960 to carry out a three-year study of the "behavioral processes" involved in self-instruction with teaching machines.

The Ford Foundation recently announced a grant to Hamilton College in Clinton, N. Y., for experimental work on automated teaching. Ford funds support a six-year curriculum organization experiment launched last year by Goddard College in Plainfield, Vt. Goddard is establishing a new "Learning Aids Center" containing teaching machines, projection rooms for films and slides, listening and recording booths with tape recorders and high fidelity reproducing equipment, and radio and television receiving rooms. The purpose is to work out a pattern of facilities that should be included in college libraries of the future.[7]

Encyclopedia Britannica, long a leading producer of instructional films, has turned its attention to development of teaching machine materials. It is sponsoring experimentation at Hollins College in Roanoke, Va., in mathematics and foreign language programs; the programs are to be ready for use next September in schools equipped with teaching machines. The *Britannica* is backing similar experiments, on a smaller scale, in Jefferson County and Littleton, Colo., the New York City area, Northbrook, Ill., and San Francisco. A Carnegie Corporation grant of $50,000 is helping to support experimentation with teaching machines at Dartmouth College. Federal grants for research on teaching machine programs of various kinds have gone to a scattering of colleges and universities across the country.[8]

Steps to Keep Teachers Abreast of New Field

School authorities had little opportunity until recently to learn much about teaching machines. The early experimentation was conducted almost entirely by psychologists and engineers whose findings were not widely circulated. Although schools were becoming increasingly receptive to

---

[7] The Council on Library Resources has granted $31,000 to the American Library Association to plan a "Library of the Future" exhibit, containing teaching machines and other modern educational devices, at the 21st Century Exposition to be held in Seattle in 1962.

[8] The list includes Brown University, Bucknell University, Earlham College, University of Houston, Indiana University, Portland (Ore.) State College, San Jose (Calif.) State College; also American Institute for Research at Pittsburgh and Edward R. Johnstone Training and Research Center at Bordentown, N. J.

the use of a variety of audiovisual aids to teaching, the teaching machine was regarded as a gadget with little applicability to classroom use. Machine instruction in the armed forces in World War II was largely ignored, in part because reports on the work were given only limited circulation and in part because military use of machines for training in mechanical operations did not attract the interest of educators in general.

The first comprehensive book on teaching machines was published last May by the audiovisual instruction department of the National Education Association. *Teaching Machines and Programmed Learning*, a 724-page volume, contains 47 reprints and nearly 200 summaries of leading reports on teaching machine research. The book serves to acquaint educators with the existing types of machines, the programs available for mechanized instruction, areas of current research, and the theories of learning which govern use of teaching machines.

An earlier book, *Automatic Teaching: The State of the Art* (1959), contained reprints of papers presented at a conference in December 1958 on "The Art and Science of the Automatic Teaching of Verbal and Symbolic Skills." The proceedings of this conference, which was sponsored jointly by the University of Pennsylvania and the Air Force Office of Scientific Research, were published "not to provide information for the implementation of school or military curricula by machine instruction, but to aid the researcher." The U.S. Office of Education and the Institute for Communication Research of Stanford University sponsored a meeting of scholars on Nov. 13-14, 1959, to discuss the state of research in instructional television and tutorial machines. Proceedings of this meeting were published in a paperback, *New Teaching Aids for the American Classroom* (1960).

The Office of Education made a grant of $103,000 to the National Education Association late in 1960 to finance an 18-month study of technological developments in education and their effect on teaching. The study, which will deal with teaching machines, television, language laboratories and all other types of audiovisual aids, is under the direction of James D. Finn, educational professor and chairman of the audiovisual department of the University of Southern California. "Education . . . is going through a

technological revolution," Finn said after the grant was announced on Nov. 21. "This creates serious problems, but at the same time it has developed trends of great promise. . . . It is no exaggeration to say that the profession is looking for and badly needs an assessment of these movements which will provide the basis for intelligent action in the future."

Another effort to "carry the word" to the teaching profession has been initiated by the Learning Resources Institute in New York City. This non-profit organization was created in October 1959 by 11 national professional educators' organizations to give guidance on televised courses for college credit and to help the profession explore the usefulness of other technical aids to learning. The Institute, which is supported by funds from private foundations and communications industries, recently began to assemble information on teaching machines and their instructional programs, with a view to offering assistance in this area.

The first national exhibition of teaching machines was held last September in the auditorium of the Department of Health, Education and Welfare in Washington. The Business Equipment Exposition sponsored by the Office Equipment Manufacturers Institute in Los Angeles last November included an extensive display of electronic teaching devices.

Characteristics of Teaching Machines

THE TEACHING MACHINE is a question-and-answer device which the student operates by himself. It differs from a quiz game in that the questions are so chosen, phrased and arranged that as the learner reads them and responds he will acquire a systematic knowledge of the subject covered.

There are two major types of teaching machines. One is adapted from the machine developed 35 years ago by the psychologist S. L. Pressey, who is generally regarded as the father of the teaching machine movement. Pressey's machine was a box about the size of a portable typewriter. It had a small window through which appeared a succes-

sion of mimeographed questions, each presenting a choice of four answers. The learner pressed one of four keys on the machine to indicate his answer to each question. If he answered correctly, the mimeographed sheet moved on to the next question; it would not move until the exposed question had been answered correctly.

Many of today's machines differ little in basic principle from Pressey's original. One of the most elaborate versions of the Pressey machine is the Subject Matter Trainer, developed under Air Force sponsorship and now used for instruction of technical specialists. This machine is a box standing chest-high; it presents a series of questions, each with a choice of 20 responses, in an aperture on the top panel. The student records answers by operating a push button; an accurate answer causes a green light to flash. The Subject Matter Trainer can be set to supply the correct answer when the learner has pushed the wrong button or to make no response until he has pushed the right button. It can be adjusted also to omit questions related to an area of knowledge which the learner has already mastered.

Another Pressey type of machine developed for Air Force use is the Auto Tutor. It exposes a series of pages of information and graphic material on a screen. After study, the learner selects his choice of suggested answers to questions by pushing a code number on a keyboard. A flash on the screen indicates an error; the appearance of another page of study material indicates that the previous question has been answered correctly. The machine keeps a record of the trainee's score and the speed of his responses.

Devices to Force Pupils to Give Own Answers

Some objections have been raised to the Pressey type of machine because it uses multiple-answer questions, requiring the student to recognize the correct response but not requiring him to compose his own answer. Machines which force a pupil to give his own answers have been developed by B. F. Skinner and his associates at Harvard. Skinner's 1958 report on machines of this kind[9] described several devices which expose to the learner a series of frames containing visual material on disks, cards, or tapes. A machine for teaching arithmetic or spelling requires the pupil to respond by moving figures or letters into appropriate

[9] Reprinted in the Oct. 24, 1958, issue of *Science*, journal of the American Association for the Advancement of Science.

places. If the answer is wrong, the response is cleared and the learner must try again; if it is right, the machine automatically presents the next frame.

Another machine for the lower grades presents questions or problems in a window with a few letters or figures missing. The pupil moves levers which cause the letters or figures to appear. After composing his answer, he turns a crank; if wrong, the frame remains in position; if right, a new frame appears in the window.

Skinner machines for students from junior high school through college compel a student to compare a written response with printed material exposed by the machine. One machine presents instructional material with questions to be read through a window; the student writes his answer to each question in turn on an exposed piece of paper, then lifts a lever which causes the correct answer to appear and puts a transparent cover over the written response (to prevent cheating by erasing and copying the machine's answer). The learner repeats his run-through of the lesson until he has answered all questions correctly, the machine automatically omitting on repeat runs the questions already answered correctly.

Some variants of the Pressey and Skinner machines are small enough to be set on top of a student's desk. Devices listed in a recent issue of the *Audiovisual Communications Review* included the Card Sort Device, developed by the Air Force, to which the student responds by pushing buttons; the Multi-Purpose Self-Trainer, whose questions are answered by pulling a tab off an answer sheet; the Automatic Rater (employed by the Navy for training purposes during World War II and now used experimentally for teaching children arithmetic) which presents questions on a small screen and requires the pupil to respond by pushing one of five buttons; and the Polymath, which provides for graphic responses, like tracing a route on a map, by moving a stylus over a surface.

Adaptation of Electronic Computer to Teaching

A third type of teaching machine has been developed by adapting electronic data processors to perform an instructional function. At the Eastern Joint Computer Conference in New York in mid-December, the System Development Corporation of Santa Monica, Calif., demonstrated a

computer-instructor which had been worked out in its program to train Air Force personnel to operate a semi-automatic air defense system.

Unlike other teaching machines, which can be used by only one person at a time, the computer-teacher is capable of flashing multiple-choice questions on 100 or more small desk screens. Students simultaneously using the device need not be assembled in the same room or even the same building. Each selects his answers to questions on his screen by pressing a button on an electronic keyboard. If the answer is correct, the next question appears on the screen; if it is wrong, the computer presents a series of simpler questions that lead the learner step by step to the missed question. Each student thus moves ahead at his own pace.

This versatile machine can present study material in the form of slides, film strips, or segments of printed pages, or it can project closed-circuit educational TV material. The classroom teacher may amend the instructional program before feeding it into the machine or may devise an independent study program. The machine is so sensitive that it can grade students not only for right and wrong answers but also for partially correct answers.

Cost of Machines; Subjects Taught by Machine

The rate at which schools and colleges move to adopt mechanized instruction will depend largely on the cost of the machines and the materials that go with them and on the effectiveness of teaching basic subjects by machine. Although some of the machines used experimentally now bear a high price tag, the cost can be expected to drop substantially as the market expands.

The computer-instructor recently demonstrated in New York now costs $50,000, and the Auto Tutor used at the Keesler Air Force Base in Mississippi costs around $5,000. But many other machines are already much less expensive. The *Wall Street Journal* reported Aug. 8, 1960, that a battery-operated device was available for only $39.50. Grolier, Inc., a new York publishing house, and Teaching Machines, Inc., of Albuquerque, N. M., recently joined to put on the market a $20 machine for home instruction in mathematics. Other machines for teaching modern lan-

guages, algebra, statistics and the fundamentals of music were offered, or will soon be offered, at prices of from $5 to $15.

The teaching machine principle can be adapted to the simplest of mechanisms, so long as the instructional material is appropriately assembled for systematic learning. The Cardboard Mask, used experimentally at Harvard, is merely a cardboard folder containing a mimeographed sheet. The text on the sheet is exposed through a window, line by line, as the student moves the sheet upward. The learner writes his answer to questions and scores himself on a separate sheet of paper.

Teaching machines were thought originally to be useful only for testing or for instruction in such limited fields as the handling of machinery and the imparting of concrete facts. But research has shown that a wide range of subjects can be taught by machine. Subjects so taught at the college level in experimental projects now or recently in progress include English, French, German, Russian and Spanish; genetics; logic, mathematics, and statistics; music theory; philosophy and psychology. Algebra, arithmetic, geometry and trigonometry, elementary science, spelling, and French have been taught experimentally in the same way in elementary or high schools.[10] Dartmouth's medical school has been experimenting with instruction by machine in anatomy, biochemistry, microbiology, pathology, pharmacology and physiology.

[10] *Audiovisual Communication Review*, Supplement I, March-April 1960, p. 9.

Probable Gains From Use of Machines

ALTHOUGH the teaching machine represents the most recent advance in educational technology, its technique of instruction harks back to the earliest days of education. The method is essentially tutorial, the machine serving as tutor to one student at a time. Like Socrates, the machine teaches by asking questions designed to draw from the student responses that will clarify the subject in his mind. The machine's concentration on the individual pupil contrasts with another trend in automation of education—giving of televised or filmed courses to ever-larger numbers of students in the traditional lecture form.

More Effective Teaching and Faster Learning

Many experimenters believe that the teaching machine is valuable, not because it introduces mechanization into the teaching process, but because it encourages development of a more effective teaching methodology. As they see it, use of the teaching machine represents a major effort to apply principles of human learning which have been discovered—and are still being discovered—through psychological research.

The key to application of these principles in mechanized teaching lies in the programs fed through the machines. The programs utilize two basic principles of successful learning:

1. Machine instruction requires the continuing participation of the student. He is never a passive receiver of information, as when he reads a textbook or listens to a teacher. The machine challenges him to make a response at every step of the way. If the questions are properly phrased, they will not only impart information but also make the student supply the connections with knowledge already possessed that will lead to his fuller understanding of the subject. This was the great value of the Socratic method, which was abandoned in the era of mass education but which can be revived with the aid of the machine.

2. The other principle made use of in teaching by machine is what psychologists call "reinforcement." This simply means that newly acquired knowledge is more firmly fixed in a student's mind when he is informed immediately whether his answer is right or wrong, and when, if the answer is wrong, he can quickly learn the correct information. The immediate satisfaction of acquiring new knowledge may be lost when a student takes a test, after weeks of soaking up facts, and then has to wait days or weeks to learn the results.

The reinforcement feature in teaching by machine has the additional advantage of stopping a student from moving ahead until he has mastered a subject up to a given point. The machine affords no opportunity to carry misconceptions into an advanced stage of study—a common occurrence, as most teachers can testify. There can be no gaps in knowledge because of absence from class or because of woolgathering while the teacher is talking.

Teaching by machine thus presents itself to educators as the most effective method yet developed for attaining the long-sought goal of individual instruction. That goal has become increasingly difficult to reach as classes have grown larger and the range of ability among students wider. Educators have sought to achieve an approximation of individual instruction by dividing classes into groups or by assigning slow and fast learners to different classes. None of these methods has proved entirely successful, because no two children can move ahead at the same rate in all subjects, and one child may be unable to progress as fast one day as another. But each pupil using a self-operated machine proceeds always at his own pace.

Proponents of teaching by machine contend that it accelerates the learning process. Edward J. Green, psychology professor at Dartmouth, has reported that the time required to learn a given body of information appears to be cut in half.

Incentive to Attentiveness and Orderly Thinking

Machine instruction depends for effectiveness on completely new study material prepared in the form of questions or problems. Programmers have found preparation of such material no easy job. The subject to be covered must be broken down into very small segments, the segments arranged in proper sequence, and carefully framed questions composed to cover each segment. Every question must be worded to elicit an answer which will push the learner only a minute step forward. Ideally, 90 per cent of each item presented to the student consists of material already familiar to him.

Programs for teaching machines therefore run to great length. Skinner has found that four grades of spelling or arithmetic may require from 20,000 to 25,000 frames in each subject. "If these figures seem large, it is only be-

cause we are thinking of the normal contact between teacher and pupil. . . . A teacher cannot supervise 10,000 or 15,000 responses made by each pupil per year. But the pupil's time is not so limited. In any case, surprisingly little time is needed. Fifteen minutes per day on a machine should suffice for each of these programs." [11]

Teaching by machine calls for a new method of grading. Every student who has successfully completed a machine-taught course has a theoretically perfect record in the course. "In traditional practice," Skinner has written, "a C means that a student has a smattering of a whole course. But if machine instruction assures mastery at every stage, a grade will be useful only in showing how far a student has gone; C might mean that he is half way through a course. Given enough time, he will be able to get an A. . . . The quick student will meanwhile have picked up A's in other subjects." Students obviously differ in their capacity to apply the knowledge gained, but "the kind of individual difference which arises simply because a student has missed part of an essential sequence . . . will simply be eliminated."

Perhaps the most revolutionary feature of this kind of teaching, from the student's standpoint, is that the questions asked are "easy." That is, they are worded to contain cues that elicit the correct answer.[12] In some instructional programs, the number of cues to the correct answer is progressively reduced as the course proceeds. Skinner has observed that many teachers, accustomed to asking difficult questions in order to challenge students to think, may be appalled at this "effort to maximize success and minimize failure." The usual procedure of such teachers has been to hold a student's attention by keeping him in fear of failing. But Skinner maintains that anxiety of this kind contributes nothing to the learning process. He has found no evidence that "struggling through difficult material" increases a student's power to think or that what is easily learned is readily forgotten. "A more sensible program would be to analyze the behavior called 'thinking' and produce it according to specifications."

> Immediate feedback [instant scoring of students' answers] encourages a more careful reading of programmed material than

[11] B. F. Skinner, "Teaching Machines" (Reprint of 1958 report to Fund for the Advancement of Education), *Teaching Machines and Programmed Learning* (1960), p. 146.

[12] Any machine program that consistently produced wrong answers to the extent of more than 10 per cent would be considered faulty and in need of revision.

> is the case in studying a text, where the consequences of attention or inattention are so long deferred that they have little effect on reading skills. The behavior involved in observing or attending to detail . . . is efficiently shaped by the contingencies arranged by the machine. And when an immediate result is in the balance, a student will be more likely to learn how to marshal relevant material, to concentrate on specific features of a presentation, to reject irrelevant material, to refuse the easy but wrong solution, and to tolerate indecision, all of which are involved in effective thinking.

On the other hand, Skinner concedes that students may become too dependent on the machine and less able to cope with the "inefficient presentations of lectures, textbooks, films and 'real life.'" Good teachers must meet this problem by "weaning" students from the machine, and the final stages of programmed learning "must be so designed that the student no longer requires the helpful conditions arranged by the machine." Most students in Skinner's experimental programs reported that they acquired more knowledge from the machine in less time and with less effort than by conventional methods of learning.

Aid to Teachers in Period of Heavy Enrollments

If the benefits of learning by machine derive solely from the program of instruction, the question arises: Why bother with the machine at all? At least one school superintendent—Carl F. Hansen of the District of Columbia system—plans to try out a new machine learning program without using the mechanical device itself because it proved too costly for his budget. This program comes in the form of a work-book, consisting of 2,600 problems in grammar, each followed by the correct answer. The work-books will be tried out on a group of sixth grade pupils.

The advantages of mechanizing such a program lie largely in the ability of the machine to meet the problems raised by increasing enrollments and teacher shortages. Under ideal conditions each pupil would be tutored individually by a teacher skilled in the techniques of programmed learning, but a tutorial system of this kind obviously cannot be adopted in most schools. However, the machine can substitute for a tutor to surprising extent.

Teaching machines are welcomed on another score. Expansion of knowledge in most fields and growth of demands for highly educated citizens have greatly enlarged the body of knowledge to be acquired during school years. The

period of preparation for professional competence in the various specialties has already been extended well into the adult years. If teaching machines can really raise learning efficiency, that period might be shortened.

If tutorial machines win extensive acceptance, what then will be the function of the classroom teacher? All participants in the teaching machine movement give assurance that human teachers will not be supplanted but will be freed to function on a higher level. However, they do not say precisely what is meant thereby, beyond suggesting that teachers could devote more time to leading classroom discussions and giving individual counseling.

Writing of the impact of both the tutorial machines and instructional television, Schramm has said that they provide "a way to relieve the present overworked and overchallenged classroom teacher from some of the drudgery of teaching facts and skills, from some of the drilling, from trying to appear expert in more subjects than anyone can possibly be expert in, from trying to provide more demonstrations and trips and visits than any one school can possibly provide."

> By relieving the teacher of such time-consuming, thankless, and often inefficient or impractical activities, they [the machines] offer a chance to free time to help individual students, and to help all students acquire the abilities to solve problems, think critically, appreciate art and literature, and develop their creative and inventive talents—kinds of teaching which are not done so well by machine—and thus to raise the quality of education generally.[13]

Highly skilled teachers would have still another and newer role—that of serving with subject specialists and psychologists on the teams which prepare instructional programs for the machines.

Place of Machines in Era of Educational Change

The teaching machine has come to the fore at a time when American education seems ripe for fundamental changes. Nearly 30 years ago Pressey complained that education was "the one major activity in this country which is still in a crude handicraft stage." He felt that, as a "large-scale industry," it ought to use "quantity production methods." [14] Today education is apparently ready for its

[13] Stanford Institute for Communication Research, *New Teaching Aids for the American Classroom* (1960), p. vii.

[14] S. L. Pressey, "A Third and Fourth Contribution Toward the Coming 'Industrial Revolution' in Education," *School and Society*, Nov. 19, 1932, reprinted in *Teaching Machines and Programmed Learning* (1960), p. 47.

belated "industrial revolution." Schramm observed recently that "it seems uncommonly good fortune that such devices should come into use just at the time when our schools are being challenged both in quantity and quality." The summary of proceedings at an Association for Higher Education conference in Chicago stated: "We have entered a new era in education in which newly available resources for learning may be as revolutionary in their effect as the invention of books in an earlier day." [15]

Preparation of instructional programs for machines is proceeding coincidentally with modernization of basic school curriculums, notably in mathematics and science. The use of self-instructional machines fits in, moreover, with growing support among educators for more independent study on the part of students.

A sense of change pervades the field of education. An English professor has gone so far as to note passing of the "print culture" as the printed page ceases "to constitute the major basis for teaching and learning and is no longer the dominant technological form of our world." [16] Alvin C. Eurich, director of the Fund for the Advancement of Education, has called on educators to examine critically certain long-held "shibboleths" about education—that small classes are better than large classes or that a certain minimum number of years in school is necessary to acquire a good education. "The total effort in education must be concerned with the intelligent utilization of our teachers and any new means of communication that may stimulate and facilitate learning." [17]

Future use of teaching machines will necessarily be dovetailed with use of televison, tape recordings, language laboratories and other devices rapidly coming into school use. Authorities believe that it will be important to develop instructional materials that coordinate the use of all of these devices so that maximum benefits can be gained from each. For example, televised courses may be prepared in future on the assumption that students have already covered the groundwork by machine study, or the TV courses may be introductory to more advanced study by machine.

---

[15] Association for Higher Education, *Current Issues in Higher Education* (1959), p. 59.

[16] Marshall McLuhan, "Electronics and the Changing Role of Print," *Audiovisual Communication Review*, September-October 1960, p. 74.

[17] Alvin C. Eurich, "New Strategy for America's Schools," *Saturday Review*, Sept. 3, 1960, p. 36.

Programs using tape recorders and instructional films in connection with machine study have already been developed.

Design of school buildings hereafter will have to take into account the need for small rooms or booths for independent machine study and large rooms for television classes. Not all educators are happy about the prospect; fears are expressed that the human element will be taken away from teaching, that too much uniformity and inflexibility will result from widespread use of "master" courses, that a fully acceptable theory of learning has not yet been formulated to give sound direction to development of "programmed learning."

It has been suggested that the task of finding answers to these objections, and of filling gaps in knowledge of how to make the best use of automation in education, should be sought through a continuing research and development program. Such a program would perform for education the same service that government-financed experimental stations perform for agriculture. Eurich recommended that each state create a commisson on educational development to sponsor experiments and promote adoption of successful new devices and procedures in education. A conference of scholars, sponsored by the Learning Resources Institute last November, proposed establishment of 10 such regional research and development stations across the country.